FY 2002 Prospectus for Mapping and Geographic Analysis

PROJECT TITLE: Feature Extraction from Multimodal Sources to Support the National Map

PRINCIPAL INVESTIGATOR(S):

E. Lynn Usery

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George Timson, Computer Scientist, USGS, Rolla, MO

DURATION OF PROJECT: **1 year**

FY 2002 FUNDING REQUEST: **$ 130,632**

STUDY AREA/REGION(S): Coastal North Carolina, Camp Lejune
RESEARCH THEME(S): Feature extraction for National Map from remotely sensed data

KEY WORDS: National Map, features, extraction, image data, knowledge base

ABSTRACT: The accomplishment of the National Map vision will require significant research in cartography, remote sensing, and geographic information science. Current cartographic processes such as generalization and feature extraction pose fundamental hurdles to National Map implementation. The establishment of a feature ontology for the National Map is also requisite for implementation. This proposed research will begin an investigation of the problem of feature extraction from available image and map database sources to help establish a framework for implementation of the National Map. The research approach is to build a knowledge base of 20 specific features for inclusion in the National Map and develop a table of probabilities for extraction of those features from current image sources. The design uses databases of features coupled through rules, methods, procedures, and heuristics with image responses and map representation to develop a tool to support feature extraction through a combination of automatic and interactive techniques. The project will incorporate results from two existing projects, one internal USGS project exploring feature structures and theory, and the second at the University of Georgia, supported by the National Imagery and Mapping Agency (NIMA), to examine feature extraction from multimodal sources for Littoral Warfare Database (LWD) construction. Expected products from this research include a knowledge base framework

and implementation for supporting feature representation and extraction for the National Map and a specific knowledge base of 20 features with associated tables of extraction probabilities. The knowledge base will be expandable to include other features and image sources.

BACKGROUND: The vision of the National Map provides a coherent goal for the unified development of spatial data to meet the needs of the U.S. Federal government in 2010. That vision requires the U.S. Geological Survey (USGS) to research, develop, and implement methods to generate digital map products from a variety of high spatial, spectral, radiometric, and temporal resolution sources. The realization of the National Map concept mandates that the USGS invest significant resources in cartographic research including topics such as generalization and feature extraction from a variety of image data sources.

The needs of the National Map are for high spatial and temporal resolution data that can be distributed in digital and hardcopy forms. The currency requirement mandates the ability to quickly generate needed National Map data themes. In essence the databases supporting the National Map must contain features and detail compatible with USGS map products – and plotted to within <5 m of their correct planimetric positions as referenced to the World Geodetic System of 1984 datum (WGS84) (Doyle, 1997). Thus, there are several exacting requirements: 1) extreme detail; 2) high geometric accuracy; and 3) rapid assimilation.

The data that will comprise the National Map will include orthophotos, elevations, vector themes such as hydrography, transportation, structures, boundaries of governmental units and administrative boundaries of publicly owned lands, geographic names, and land characterization The characteristics of the data will include currency within days, seamlessness, variable resolution and completeness, consistency and integration among themes, and variable positional accuracies (USGS, 2001). With the exception of geographic names and boundaries, all themes proposed for the National Map may be automatically or interactively extracted from image sources either directly or in combination with other data. These sources include photographic, multispectral, hyperspectral, lidar, radar, sonar, high spatial resolution commercial sensors, and a variety of hand-held camera and video images along with *in situ* sensors correlated to geographic positions with Global Positioning System (GPS) data. These multimodal sources can be used to support extraction of a variety of features for the National Map through both automated and interactive on-screen digitizing techniques. The paradigm for gathering geospatial data is rapidly changing from single agency, specifications-driven data collection to this multimodal plethora of data from which maps and their derivatives can be extracted.

This project is proposed as a pilot research investigation to determine a starting point for feature extraction from these varied sources to support National Map objectives. The project will leverage results from ongoing work from a National Imagery and Mapping Agency (NIMA) grant to the University of Georgia under NIMA's University Research Initiative program. That work, "Optimization of Coastal Zone Databases Using Multimodal Data," PI-Roy Welch and CoPI-E. Lynn Usery, has objectives of determining the probabilities of extracting specific features for NIMA's Littoral Warfare Database (LWD) from multimodal data sources. NIMA's LWD requirements are similar to those of the National Map in terms of detail level, geometric accuracy, and rapid assimilation. With similar requirements, it is proposed that a similar approach can be used to determine probabilities of extracting features for the National Map.

In order to meet these requirements, consideration must be given to extracting high-resolution detail from remotely sensed data recorded by both traditional overhead sensor systems (e.g., aerial photographs, Ikonos stereo satellite images and SPOT/Landsat digital multispectral images) and non-traditional sensor systems (hyperspectral, radar, lidar, small format handheld digital cameras and towed arrays), and merging it with topographic and bathymetric information obtained from existing sources such as USGS DLG-3, NHD, DEM, DOQ, DRG, and land characterization databases (Li, 1998). It is also desirable to establish links between the analyst engaged in feature extraction and a computer knowledge base containing information about National Map features to allow the compilation/update of both paper and digital cartographic products meeting USGS requirements over a range of scales. To-date, the ability to develop, from a single database, cartographic products meeting both operational and planning needs at a range of scales has not been effectively demonstrated.

Mapping from satellite image sources has been heavily researched with significant results (Welch, 1977; Welch, 1982a; 1982b; Welch and Usery, 1984; Welch, 1985a; 1985b; Gugan and Dowman, 1988; Hartley, 1988; Ley, 1988; Welch and Jordan, 1997; Welch et al., 2000). Geographic feature extraction for database construction from image sources has also been the source of intensive research for several decades with somewhat mixed results (Welch et al, 1995;Usery and Welch, 1989). While the human eye can easily detect, recognize, and identify specific geographic features, the encoding of that ability into completely automated systems has defied researchers. Significant progress has been made at coding low-level image processing algorithms such as image segmentation and edge detection (Vanderbrug, 1976; Benjamin and Gaydos, 1984; Cleynenbreugel et al., 1990; Lillesand and Kiefer, 2000; Jensen, 2000). High level processing methods which assimilate low level results into features of interest in mapping and analysis have been more difficult to implement (Bajcsy and Tavakoli, 1976; Argialas and Harlow, 1990; Schenk and Zilberstein, 1990). Additional work with knowledge bases (McKeown, 1986; McKeown and Lai, 1987; Usery et al., 1988), artificial neural networks and self organizing maps (SOM's) (Ji, 2001) have met with limited success, however, a completely automated robust system for feature extraction and map construction still eludes researchers.

Feature extraction relies on an adequate definition of a feature's existence (ontology) and coding of appropriate attributes and relationships. The National Map will require an ontology of features to be included on the various themes. The design and development of such an ontology will require significant research drawing from existing USGS feature sets such as DLG-3, DLG-E, and NHD and incorporating recent theoretical developments in geographic ontological research (Guptill et al., 1990; Mark et al., 2001; UCGIS, 2001). A complete ontology for the National Map is a long-term research requirement to which this research proposes to make a small contribution. That contribution is in the selection, design, and development of 20 specific features. The features will be defined with appropriate attributes and relationships to support incorporation in National Map themes and to support extraction from remotely sensed sources.

HYPOTHESIS/QUESTION:

We hypothesize that a sufficient set of geographic features to support spatial and temporal resolution requirements of the National Map can be extracted from multimodal image sources through a combination of automated and interactive on-screen digitizing techniques. These techniques can be implemented economically and rapidly through the use of pre-existing knowledge of the capabilities of extracting specific features from specific image sources and combinations of image sources such as image fusions. The objectives of this project are thus to select a limited set of 20 features appropriate for inclusion in National Map databases and determine the probabilities of extracting these features from existing image sources.

APPROACH: The approach for determining feature extraction probabilities rests on building an appropriate knowledge base comprised of: 1) a database of features with associated attributes and relationships, 2) a database of responses for the features from specific image sources including image chips of the features, 3) a database of representation of these features on specific products which are a part of the National Map, and 4) a set of rules, heuristics, and methods for feature extraction and representation of the features (Figure 1).

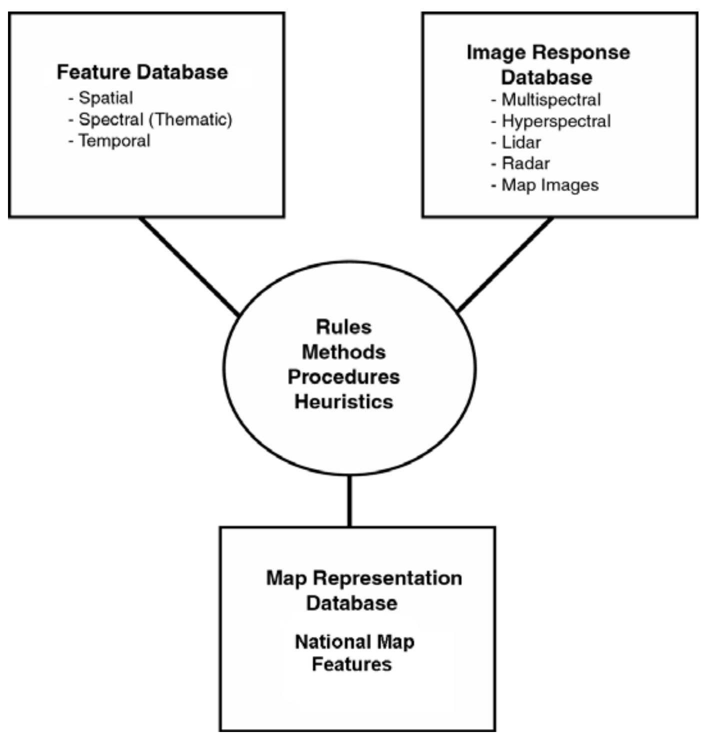

Figure 1: Design of the knowledge base for feature extraction for National Map.

The feature database in the construction of this knowledge base will use data structures and models developed and tested under GRA Task 740 Multiple Representation and a Multidimensional Theory of Geographic Features and Relations. The theory and implementation from this project has demonstrated a comprehensive feature-based system that can be used as a generic method of feature representation and can support applications including feature extraction and knowledge base construction (Usery, 2000).

The initial work will be to determine common features from the USGS feature set with the LWD features defined on the NIMA project. It is anticipated that there are many common features from which 20 will be selected to test and determine extraction probabilities.

Knowledge Base Development

The three databases that comprise the knowledge base will be independent developments integrated into a complete feature extraction system. The Feature Database model and initial implementation was developed under GRA Task 740. The model is currently being tested with a watershed/water modeling application in which features exist as entities in the real world and have locational, thematic, and temporal attributes and relationships attached. The object-oriented design builds from DLG-F concepts and supports multiple geometries of feature representation including vector (points, lines, polygons) and raster (grids and fields) (Tang et al., 1996; Usery, 1994a; Usery, 2000). This structure is ideal for defining features from multimodal image sources and supporting rule bases for extraction (Usery, 1994b; 1996a; 1996b).

The Image Response database is comprised of links to features from the Feature Database with specific image attributes associated. For example, a runway would be defined in the Feature Database with geographic location and extent, name, relations to other features, e.g., the airport of which it is a part, and other relevant attributes and relationships to establish the features existence. The same runway in the Image Response database will include spectral responses for the asphalt or concrete comprising the surface and image chips of the runway captured from all existing sources, e.g. DOQ's, DEM's, Landsat Thematic Mapper, Ikonos, radar, lidar, and hyperspectral sources. Merged or fused image data will also provide spectral responses and image chips for this database and may provide higher probabilities for extraction (Welch, 1987; Welch and Ehlers, 1987; Welch and Ehlers, 1988).

The Map Representation database will contain map specifications for inclusion and symbolization of the features on specific products, e.g., USGS 1:24,000-scale quadrangles and sample representation in the form of cartographic symbols and image segments from DRG's. The runway feature discussed above would include its symbology on 1:24,000-scale maps and a small DRG segment illustrating its portrayal on that product (Usery, 1994b).

These three databases are linked by feature identifiers so a knowledge structure can use information from all the databases to determine a course of action, in this case the probability of extracting the feature automatically or through interactive on-screen digitizing. The knowledge base becomes a user tool for examining the extraction capability from specific sources and for multiple representations of the features (Usery, 1994a; Usery, 1994b).

Feature Extraction Approach

The testing of feature extraction from multimodal sources will be implemented as a set of rules and methods shown in the center of Figure 1. The approach is to use existing automated methods including low level image processing operators and the higher level knowledge structures developed from the knowledge base to link the feature attributes with the image sources and map representation. Methods of extraction which show promise can be tested and the results used to development the probability tables. The actual methods of extraction will use current methodologies such as Bayesian classification, fuzzy classification (Wang, 1990; Katinsky, 1994; Usery, 1996b; 1996c; Seong and Usery, 2000) neural networks and non-neural textural classifiers (Usery and Pape,1995; Pape,1998) and other methods available in the literature (Welch and Remillard, 1996; Welch et al., 1999).

Study Site

The features selected will be representative of coastal areas and will exist in the Camp Lejune, North Carolina area. This site was selected to correspond to the site for the NIMA LWD feature extraction research. Advantages are the ongoing work for NIMA, availability of multimodal datasets, and the expertise of the investigators from prior work in the area. Data sets available include USGS DLGs, DRGs, DEMs, and DOQs; Ikonos, Landsat TM, and SPOT panchromatic and multispectral images; and radar, lidar, and hyperspectral data. NIMA topographic and NOAA bathymetric datasets are also available.

PRODUCTS: Documentation of initial work toward defining attributes and relationships of specific features that are a part of an ontology for the National Map will be developed. A table of probabilities for extraction of specific features from multimodal image sources and a knowledge base for these features with feature ontology, image response and map respesentation components will also result from the research. This knowledge base will provide a basis for further development and refinement of the National Map concept and implementation.

The theoretical investigation of features and extraction from multimodal sources will yield several publications. Expected results are anticipated to support publication in the following areas:

1) Feature ontology and representation in data and knowledge bases. Target journal – *Cartography and Geographic Information Science*.
2) Feature extraction approaches and probabilities from multimodal sources. Target journal – *Photogrammetric Engineering and Remote Sensing*.
3) Knowledge base system design and implementation for feature extraction. Target journal -- *International Journal of Geographic Information Science*.

PROJECT PERSONNEL QUALIFICATIONS: Briefly describe the roles and responsibilities of the individual in the first paragraph of the vitae. Next summarize their qualifications. Include education and relevant work experience, accomplishments, and references.

Principal Investigator

Dr. Usery will serve as the principal investigator responsible for coordination of all project activities at both USGS and UGA. He will manage the research activity at MCMC in cooperation with Mr. Timson who will manage the programming of the feature system and the knowledge bases. Dr. Usery will also manage the research at UGA, coordinating with Dr. Welch to incorporate results from the NIMA project and directly supervising the graduate student and programming effort at UGA. Dr. Usery will be directly responsible for the development of the National Map feature set to be investigated, design of the knowledge base including the feature, image, and map representation database components, and the primary source for developing the rules and heuristics for feature ontology and representation in the National Map themes.

NAME:	E. Lynn Usery
RANK:	Associate Professor, University of Georgia Research Geographer, U.S. Geological Survey
DEPARTMENT:	Geography, The University of Georgia

EDUCATION:	B.S.	1974	University of Alabama, Geography
	M.A.	1977	University of Georgia, Geography.
	Ph.D.	1985	University of Georgia, Geography.

EMPLOYMENT HISTORY:

1977-1983	U.S. Geological Survey, Rolla, Missouri, Cartographer
1983-1988	U.S. Geological Survey, Rolla, Missouri, Geographer
1988-1993	University of Wisconsin - Madison, Assistant Professor
1994-1997	University of Georgia, Athens, Georgia, Assistant Professor
1997-Present	University of Georgia, Athens, Georgia, Associate Professor
1999-Present	Research Geographer, U.S. Geological Survey, Rolla, Missouri.

RESEARCH INTEREST AND RELEVANT EXPERIENCE:

Dr. Usery conducts research in geographic information science, including geographic information systems, remote sensing and cartography with publications on theoretical aspects of geographic representation, human cognition of geographic phenomena, automatic feature extraction from images, and visualization, and applications of geographic information science to precision farming, watershed modeling, and water quality. He has worked extensively with geographic feature ontologies serving as a member of the USGS team that developed the Digital Line Graph-Enhanced (DLG-E) feature set and as a USGS representative supporting the Defense Mapping Agency's development of the Feature Attribute Coding Standard (FACS). His current research includes developing and implementing a multidimensional theory of geographic phenomena, multiple representations, map projections, autostereoscopic visualization, and resolution effects on watershed and water quality modeling and analysis. Dr. Usery currently serves as Chair of the Research Committee for the University Consortium for Geographic Information Science (UCGIS) and is Vice President of the Cartography and Geographic Information Society.

HONORS AND AWARDS:

Chair, Commission IV/1 Working Group, Geographic Information System Data and Applications, International Society for Photogrammetry and Remote Sensing, (1992-1996).

1995, Connecting Teachers with Technology, Faculty Development Award, University of Georgia.

1986, Dissertation Award, Sigma XI.

BOOKS (AUTHORS AND EDITOR):

Usery, E.L., (ed), *1995. Proceedings, Workshop on Mapping and Environmental Applications of GIS Data, International Archives of Photogrammetry,* Volume XXX, Part 4W2, 166 p.

NUMBER OF ARTICLES PUBLISHED IN REFEREED JOURNALS: 19

RELEVANT PUBLICATIONS:

Usery, E.L. and J.C. Seong, 2001. All Equal Area Map Projections are Created Equal, but Some are More Equal than Others, *Cartography and Geographic Information Science,* Vol. 28, No. 3, pp. 183-193.

Seong, J.C. and E.L. Usery, 2001. Modeling Raster Representation Accuracy Using a Scale Factor Model, *Photogrammetric Engineering and Remote Sensing*, Vol. 67, No. 10, pp. 1185-1191.

Usery, E.L., 2000. Multidimensional representation of geographic features. *International Archives of Photogrammetry and Remote Sensing, Volume XXXIII, Part B4/3, Commission 4,* pp. 240-247.

Seong, J.C. and E. L. Usery, 2001. Fuzzy image classification for continental-scale multitemporal NDVI series using invariant pixels and image stratification method. *Photogrammetric Engineering and Remote Sensing*, Vol. 67, No. 3, 287-294.

Kazmi, S.J.H. and E. L. Usery, 2000. Application of remote sensing and GIS for the monitoring of diseases: A unique research agenda for geographers. *Remote Sensing Reviews,* Vol. 20, No. 1, pp. 45-70.

Mozolin, M., J.C. Thill, and E.L. Usery, 1999. Trip distribution forecasting with multilayer perceptron neural networks: A critical evaluation. *Transportation Research Part B*, Vol 34, pp. 53-73

Usery, E.L., J.C. Seong, B.W. Jun, 1998. Implementing GIS software over the World-Wide-Web. *Proceedings, American Society for Photogrammetry and Remote Sensing Annual Convention*, Tampa, Florida, CD-ROM Publication.

Usery, E.L., 1996. A feature-based geographic information system model. *Photogrammetric*

Engineering & Remote Sensing, Vol. 62, No. 7, pp. 833-838.

Usery, E.L., 1996. A conceptual framework and fuzzy set implementation for geographic features. *In* Burrough, P. A. and A.U. Frank, (eds.), *Geographic Objects with Indeterminate Boundaries*, Taylor and Francis, London, pp. 71-85.

Tang, A.Y.S., T. Adams, and E.L. Usery, 1996. A spatial data structure design for a feature-based GIS. *International Journal of Geographical Information Systems*, Vol. 10, No. 5, pp. 643-659.

Usery, E.L., 1996. Membership functions for fuzzy set representation of geographic features. *International Archives of Photogrammetry, Volume XXXI, Part B4*, p. 881-883.

Usery, E.L. and D. Pape, 1995. Extracting geographic features from raster data. *Proceedings, American Society for Photogrammetry and Remote Sensing Annual Convention*, Charlotte, North Carolina, pp. 733-740.

Usery, E.L., 1994. Implementation constructs for raster features. *Proceedings, American Society for Photogrammetry and Remote Sensing Annual Convention*, Reno, Nevada, pp. 661-670.

Usery, E.L.,1994. Display of geographic features from multiple image and map databases. *Proceedings, International Society for Photogrammetry and Remote Sensing, Commission IV Symposium on Mapping and Geographic Information Systems*, *International Archives of Photogrammetry, Volume XXX, Part B4*, Athens, Georgia, pp. 1-9.

Graff, L.H. and E.L. Usery, 1993. Automated classification of basic-level terrain features in digital elevation models. *Photogrammetric Engineering and Remote Sensing*, Vol. 59, No. 9, pp. 1409-1417.

Co-principal Investigator

Dr. Welch will serve as Co-Principal Investigator on the project. His research management responsibility will include coordinating activities and results from the NIMA project to address research needs and helping the PI direct the research effort at UGA. Dr. Welch will be principally responsible for the assessment and evaluation of image sources for National Map feature extraction.

NAME: Welch, Roy A. (Principal Investigator)
RANK: Director and Research Professor
DEPARTMENT: Center for Remote Sensing and Mapping Science, Geography
The University of Georgia

EDUCATION:	B.S.	1961	Carroll College, Waukesha, Wisconsin , Geography and Biology
	M.A.	1965	University of Oklahoma, Norman, Physical Geography
	Ph.D.	1968	University of Glasgow, Scotland, Remote Sensing, Photogrammetry, Cartography

EMPLOYMENT HISTORY:

1962-1964 Photo-Analyst with the U.S. Government

1968-1969 Manager, Earth Sciences Department, Itek Corporation
1969-1971 National Academy of Sciences-National Research Council Research Associate with US Geological Survey
1971-1973 Assistant Professor, Geography Department, University of Georgia
1973-1977 Associate Professor, Geography Department, University of Georgia
1977-1980 Professor, Geography Department, University of Georgia
1980-present Research Professor, Geography Department, University of Georgia (Marine Science, 1993 and Ecology, 1995)

RESEARCH INTERESTS: Integrated remote sensing and geographic information systems (GIS) applications in the physical, biological and geological sciences; digital image processing; and mapping software development.

HONORS AND AWARDS:

Chair, Commission IV Working Group 2, Digital Terrain Models, Orthoimages and 3D GIS, International Society for Photogrammetry and Remote Sensing, (1996-2000).

Inventor of the Year, The University of Georgia Research Foundation, (1996).

President, Commission IV, Mapping and Geographic Information Systems, International Society for Photogrammetry and Remote Sensing, (1992-1996).

Elected *Fellow of the American Society for Photogrammetry and Remote Sensing*, (1995).

Alan Gordon Memorial Award, American Society for Photogrammetry and Remote Sensing, for contributions to desktop mapping with personal computers, including digital photogrammetry, radargrammetry, and three-dimensional terrain visualization, (1993).

President, American Society for Photogrammetry and Remote Sensing, (1984-1985).

Sigma Xi Active Member Research Award for significant research on the cartographic applications of satellite imagery, (1982).

Fairchild Photogrammetric Award, American Society for Photogrammetry and Remote Sensing, for research leading to significant contributions in remote sensing, in assessment of image quality and digital image processing, (1981). (This is the highest award of the American Society for Photogrammetry and Remote Sensing).

Creative Research Medal, The University of Georgia Research Foundation, Inc. for remote sensing studies of land use changes in China, (1981).

NUMBER OF ARTICLES PUBLISHED IN REFEREED JOURNALS: ~160

BOOKS (AUTHOR AND EDITOR):

Welch, R., M. Madden, R. Doren and K. Rutchey (Eds.) 1999. Mapping Vegetation in the Everglades, Special Issue, Photogrammetric Engineering & Remote Sensing, Vol. 65, No. 2.

Welch, R. and M. Remillard (Eds.) 1996. ISPRS Commission IV: Mapping and Geographic Information Systems, Special Issue, ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 51, No. 4.

Welch, R. and M. Remillard (Eds.) 1994. Mapping and Geographic Information Systems, *International Archives for Photogrammetry and Remote Sensing*, Vol. 30, Part 4, 710 pages.

RELEVANT PUBLICATIONS FROM PAST FIVE YEARS:

Welch, R., T. Jordan and M. Madden, 2000. GPS surveys, DEMs and scanned aerial photographs for GIS database construction and thematic mapping of Great Smoky Mountains National Park, *International Archives of Photogrammetry and Remote Sensing,* Vol. 33, Part B4/3: 1181-1183.

Welch, R., Madden, M. and R. Doren, 1999. Mapping the Everglades, *Photogrammetric Engineering and Remote Sensing*, 65(2): 163-170.

Welch, R., T. Jordan, H. Lang and H. Murakami, 1998. ASTER as a Source for Topographic Data in the Late 1990s, *IEEE Transactions of Geoscience and Remote Sensing*, vol. 36, no. 4, pp. 1282-1289.

Welch, R. and T.R. Jordan, 1997. Comparative Mapping from High Resolution Satellite Images and Scanned Aerial Photographs, *Technical Papers of 1997 ACSM/ASPRS Annual Convention and Exposition*, Seattle, April 7-10, Vol. 3, pp. 483-484.

Welch, R. and T.R. Jordan, 1996a. Digital Orthophoto Production in a Desktop Environment, *GIM Magazine*, Vol. 10, No. 7 (July), pp. 26-27.

Welch, R. and T.R. Jordan, 1996b. Using Scanned Air Photographs, In *Raster Imagery in Geographic Information Systems*, (S. Morain and S.L. Baros, eds), Onward Press, pp. 55-69.

Welch, R. and M. Remillard, 1996a. GPS, image processing and GIS techniques for coastal wetland mapping applications, *International Archives of Photogrammetry and Remote Sensing,* Vol. 31, Part B4: 931-933.

Welch, R. and M. Remillard, 1996b. GPS, photogrammetry and GIS for resource mapping applications, In, (Clifford W. Greve, Ed.) *Digital Photogrammetry: An Addendum to the Manual of Photogrammetry*, American Society for Photogrammetry and Remote Sensing, Bethesda, MD: 183-194.

Welch, R., M. Remillard and R. Doren, 1995. GIS database development for South Florida's National Parks and Preserves, *Photogrammetric Engineering and Remote Sensing*, 61(11): 1371-1381.

Co-principal Investigator

Mr. Timson will be responsible for managing the programming development at MCMC and coordinating the programming effort at UGA through the PI. Mr. Timson will have primary responsibility for all program development including the implementation of the feature design, database development and the implementation of the rules and heuristics for feature representation and extraction. Mr. Timson will also bring his expertise in feature system development and provide integration of previous USGS developments such as DLG-F into the project.

NAME: George R. Timson
RANK: Computer Scientist, U.S. Geological Survey

EDUCATION: B.S. 1986 University of Missouri-Rolla, Computer Science

EMPLOYMENT HISTORY:

1986-Present U.S. Geological Survey, Rolla, Missouri, Computer Scientist

RELEVANT EXPERIENCE:

Mr. Timson has worked extensively with feature based data modeling and feature maintenance. His efforts include development of a prototype system that demonstrated the feasibility of feature-based cartographic systems, development of feature-based revision capabilities for a pilot data exchange between USGS and the Bureau of Census, being part of the development team for the USGS National Hydrography Database, and development of the Feature Communication Protocol which enables the concept of transactional updates between two feature-based systems.

HONORS AND AWARDS:
1996, Superior Service, United States Department of the Interior.

RELEVANT PUBLICATIONS:

D. Arctur, D. Hair, G. Timson, E. P. Martin, and R. Fegeas, 1998. "Issues and prospects for the next generation of the spatial data transfer standard (SDTS)." *International Journal of Geographical Information Science,* Vol. 12, No. 4, pp. 403-425.

Hair D., Timson G., and Martin P., 1997. "Feature Maintenance: Concepts, Requirements, and Strategies." Version 3.0. Internal Research Report (U.S. Geological Survey).

Timson G., 1997. "Introduction to Feature Communication Protocol." Version 1.0. Internal Research Report (U.S. Geological Survey).

LITERATURE CITED:

Argialas, D.P. and Harlow, C.A.,1990, Computational Image Interpretation Models: An Overview and Perspective: Photogrammetric Engineering and Remote Sensing, 56/6, p. 871-886.

Bajcsy, R. and Tavakoli, M.,1976, Computer recognition of Roads from Satellite Pictures: IEEE Transactions on Systems, Man, and Cybernetics, SMC-6/9, p. 623-637.

Benjamin, S.P. and Gaydos, L.,1984, Processing of Scanned Imagery for Cartographic Feature Extraction: Proceedings, Pecora 9, Sioux Falls, S.D., p. 222-230.

Cleynenbreugel, J.V., ierens, F., Suetens, P. and Oosterlinck, A.,1990, Delineating Road Structures on Satellite Imagery by a GIS-Guided Technique: Photogrammetric Engineering and Remote Sensing, 56/6, p. 893-898.

Doyle, F., 1997, Map conversion and the UTM grid: Photogrammetric Engineering & Remote Sensing, 63/4, p. 367-370.

Guptill, S.C., Boyko, K.J. Domaratz, M.A., Fegeas, R.G., Rossmeissl, H.J. and Usery, E.L., 1990, An enhanced digital line graph design: U.S. Geological Survey Circular 1048, U.S. Government Printing Office, Washington, D.C.

Gugan, D.J. and Dowman, I.J.,1988, Accuracy and Completeness of Topographic Mapping from SPOT Imagery: Photogrammetric Record, 12/72, p. 787-796.

Hartley, W.S., 1988, Topographic Mapping with SPOT 1 Data: A Practical Approach by the Ordnance Survey: Photogrammetric Record, 12/72, p. 833-846.

Katinsky, M.H., 1994. Fuzzy Set Modeling in Geographic Information Systems: Unpublished Master's Thesis, Department of Geography, University of Wisconsin-Madison, Madison, Wisconsin.

Jensen, J.R., 2000, Remote sensing of the environment : an earth resource perspective: Prentice-Hall (Upper Saddle River, N.J.).

Ji, C.Y., 2001, Land use classification of remotely sensed data using Kohonen self-organizing feature map neural networks: Photogrammetric Engineering and Remote Sensing, 66/12, p. 1451-1460.

Li, R., 1998, Potential of high-resolution satellite imagery for national mapping products: Photogrammetric Engineering & Remote Sensing, 64/12, p. 1165-1170.
Lillesand, T.M. and Kiefer, R.W., 2000, Remote sensing and image interpretation: John Wiley

and Sons (New York).

Ley, R.G., 1988, Some Aspects of Height Extraction from SPOT Imagery: Photogrammetric Record, 12/72, p. 823-832.

Mark, D. M., Skupin, A. and Smith, B., 2001, Features, objects, and other things: Ontological distinctions in the geographic domain**:** forthcoming in Daniel Montello (ed.), Spatial Information Theory, Proceedings of COSIT 2001, Springer (Berlin/New York).

McKeown, D.M., 1986, The role of artificial intelligence in the integration of remotely sensed data with geographic information systems: Report CMU-CS-86-174, Carnegie Mellon University, Pittsburgh, PA.

McKeown, D.M. and Lai, R.C.T., 1987, Integrating multiple data representations for spatial databases: Proceedings, AutoCarto 8, p. 754-763.

Pape, D., 1998, Extracting Features from Raster Maps: Three Approaches: Unpublished Masters thesis, University of Georgia, Athens, Georgia.

Schenk, T. and Zilberstein, O.,1990, Experiments with a Rule-Based System for Interpreting Linear Map Features: Photogrammetric Engineering and Remote Sensing, 56/6, p. 911-917.

Seong, J.C. and Usery, E. L, 2000, Fuzzy image classification for continental-scale Multitemporal NDVI series using invariant pixels and image stratification method: Photogrammetric Engineering and Remote Sensing, 67/3, p. 287-294.

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Tang, A.Y.S., Adams, T., and Usery, E.L., 1996, A Spatial Data Structure Design for a Feature-Based GIS: International Journal of Geographical Information Systems, 10/5, p. 643-659.

UCGIS, 2001, Emerging themes in GIScience research, http://www.ucgis.org/emerging, University Consortium for Geographic Information Science.

Usery, E.L.,1996, A Conceptual Framework and Fuzzy Set Implementation for Geographic Features: In Burrough, P. A. and Frank, A.U. (eds.), 1996,Geographic Objects with Indeterminate Boundaries: Taylor and Francis (London), p. 71-85.

Usery, E.L., 1994a, Implementation Constructs for Raster Features: Proceedings, American Society for Photogrammetry and Remote Sensing Annual Convention, Reno, Nevada, p.661-670.

Usery, E.L., 1994b, Display of Geographic Features from Multiple Image and Map Databases: Proceedings, International Society for Photogrammetry and Remote Sensing, Commission IV Symposium on Mapping and Geographic Information Systems, International Archives of Photogrammetry, Volume XXX, Part B4, Athens, Georgia, p. 1-9.

Usery, E.L., 1996a, A Feature-Based Geographic Information System Model: Photogrammetric Engineering and Remote Sensing, 62/7, p. 833-838.

Usery, E.L., 1996c, Membership Functions for Fuzzy Set Representation of Geographic Features: Proceedings, International Society for Photogrammetry and Remote Sensing International Congress, International Archives of Photogrammetry, Volume XXXI, Part B4, Vienna, Austria, p. 881-883.

Usery, E.L., 2000, Multidimensional representation of geographic features: International Archives of Photogrammetry and Remote Sensing, Volume XXXIII, Part B4/3, Commission 4, p. 240-247.

Usery, E.L. and Pape, D.,1995, Extracting Geographic Features from Raster Data: Proceedings, American Society for Photogrammetry and Remote Sensing Annual Convention, Charlotte, North Carolina, p. 733-740.

Usery, E.L. and Welch, R.,1989, A Raster Approach to Topographic Map Revision: Photogrammetric Engineering and Remote Sensing , 55/1, p.55-59.

Usery, E.L., Altheide, P., Deister, R.R.P., and Barr, D.J.,1988, "Knowledge-based GIS techniques applied to geological engineering: Photogrammetric Engineering and Remote Sensing, 54/11, p.1623-1628.

USGS, 2001, The National Map, http://nationalmap.usgs.gov/nationalmap.pdf, U.S. Geological Survey, Reston, Virginia.

Vanderbrug, G.J., 1976, Line Detection in Satellite Imagery: IEEE Transactions on Geoscience Electronics, GE-14/1, p. 37-44.

Wang, F., 1990, Improving Remote Sensing Image Analysis through Fuzzy Information Representation: Photogrammetric Engineering and Remote Sensing, 56/8, p.1163-1168.

Welch, R., 1977, Height Measurements from Satellite Images: Photogrammetric Engineering and Remote Sensing, 43/10, p. 1233-1241.

Welch, R, 1982a, Spatial Resolution Requirements for Urban Studies: International Journal on Remote Sensing of Environment, 3/2, p.139-146,

Welch, R., 1982b, Image Quality Requirements for Mapping from Satellite Data, Proceedings: ISPRS International Symposium Commission 1, Canberra, Australia.

Welch, R., 1985a, Comparative Evaluations of the Geodetic Accuracy and Cartographic Potential of Landsat-4 and Landsat-5 Thematic Mapper Image Data: Photogrammetric Engineering and Remote Sensing, 51/11, p. 1799-1812.

Welch, R., 1985b, Cartographic Potential of SPOT Image Data: Photogrammetric Engineering and Remote Sensing,, 51/8, p. 1085-1091.

Welch, R., 1987, Integration of Photogrammetric, Remote Sensing, and Database Techniques: Photogrammetric Record, 12/70, p. 409-428.

Welch, R. and Ehlers, M.,1987, Merging Multiresolution SPOT HRV and Landsat TM Data: Photogrammetric Engineering and Remote Sensing, 53/3, p. 301-303.

Welch, R. and Ehlers, M.,1988, Cartographic feature extraction with integrated SIR-B and Landsat TM images: International Journal of Remote Sensing, 9/5, p. 873-889.

Welch, R. and Jordan, T.R., 1997, Comparative mapping from high resolution satellite images and scanned aerial photographs: Technical Papers of 1997 ACSM/ASPRS Annual Convention and Exposition, Seattle, April 7-10, 3, p. 483-484.

Welch, R. and M. Remillard, 1996, GPS, photogrammetry and GIS for resource mapping applications: In Greve, C.W., (ed.),Digital Photogrammetry: An Addendum to the Manual of Photogrammetry: American Society for Photogrammetry and Remote Sensing, Bethesda, MD: p.183-194.

Welch, R., Remillard, M. and Doren, R.,1995,GIS database development for South Florida's National Parks and Preserves: Photogrammetric Engineering and Remote Sensing, 61/11, p.1371-1381.

Welch, R., Jordan, T. and Madden, M., 2000, GPS surveys, DEMs and scanned aerial photographs for GIS database construction and thematic mapping of Great Smoky Mountains National Park: International Archives of Photogrammetry and Remote Sensing, Vol. 33, Part B4/3, p.1181-1183.

Welch, R., Madden, M. and Doren, R.,1999, Mapping the Everglades: Photogrammetric Engineering and Remote Sensing, 65/2, p. 163-170.

Welch, R. and Usery, E.L.,1984, Cartographic Accuracy of Landsat-4 MSS and TM Image Data: IEEE Transactions on Geoscience and Remote Sensing, GE-22/3, p. 281-288.

MISCELLANEOUS:

The project will leverage results from USGS GRA Task 740 and from the NIMA funded University of Georgia project "Optimization of Coastal Zone Databases Using Multimodal Data." The synergy among these projects is expected to benefit the proposed research and the ongoing tasks.

BUDGET:

FY 2002 PROJECT BUDGET

Project Title: Feature Extraction from Multimodal Sources to Support the National Map

Principal Investigator(s): E. Lynn Usery, Roy Welch, George Timson

PROJECT DIRECT COSTS:

		Region Performing Work			
LABOR EXPENSES		Eastern Region	Central Region	Western Region	TOTAL
Govt. Salary & Benefits			29,333		
On-site Contractor			28,750		
Subtotal Labor Costs:			58,083		
OTHER EXPENSES					
Domestic Travel			3,000		
Foreign Travel					
Supplies			1,000		
Training			2,000		
Equipment					
Cooperative Agreements/Grants	(UGA Grant)		45,113		
Contracts					
Indirect Services directly charged					
Subtotal Other Expenses:			51,113		
Subtotal Direct Costs:			**109,196**		
PROJECT INDIRECT COSTS:					
MCMC Assessment (31%)			33,850		
Division Assessment (10%)			10,919		
Subtotal Indirect Costs:			**44,769**		
TOTAL PROJECT COST:			**153,965**		
MCMC Salary contribution (1/4 GS-12 Computer Scientist)			**23,333**		
Total Request from Prospectus			**130,632**		

PROJECT BUDGET JUSTIFICATION

MCMC		
	¼ GS-12 Computer Scientist	$23,333
	¼ Contract Software Developer	28,750
	Travel	3,000
	Training	2,000
	S&E	1,000
	Summer internship (for UGA student)	6,000
	Subtotal MCMC	**64,083**
UGA		
	Salaries	
	Ph.D. Graduate student (½ time)	18,600
	Programming support (hourly)	10,000
	UGA Overhead (44.8 %)	12,813
	Travel	2,000
	Training	700
	Supplies	1,000
	SubTotal UGA	**45,113**
Subtotal Direct Costs		109,196
MCMC Assessment (31 %)		33,850
Division Assessment (10%)		10,919
Total project Costs		**153,965**
MCMC Salary contribution (1/4 GS-12 Computer Scientist)		**23,333**
Total Request from Prospectus		**130,632**

Justify all non-salary expenses.

MCMC

Travel funds will be used to support 2 project meetings of PI's and project staff, one at MCMC and one at UGA ($2,500) and presentation of results at the USGS Research Meeting and a professional society meeting such as ASPRS ($1,500).

S&E expenses ($1,000) are for computer supplies, publication, reprints, reference material purchases and other research expenses.

UGA

Travel/training funds will be used to support the PI on 2 trips ($1,000) between UGA and MCMC to manage the project. An additional trip ($1,000) to a professional meeting for the PI and the UGA graduate student to present results is included. Training funds ($700) for the graduate student in the use of commercial software are included.

S&E expenses ($1,000) are for computer supplies, publication, reprints, reference material purchases and other research expenses